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ABSTRACT

This study describes the use of VaxNotes, an electronic conferencing software, in a 16-week graduate distance learning course at a large Midwestern university. The seminar was taught at two campuses, by two instructors, connected by video and audio distance learning technologies. Discussions held outside class were conducted initially by electronic mail (e-mail), later using VaxNotes. The instructor provided guidelines for the student electronic discussion, and participation was worth 25% of the final class grade. Notes were collected from the e-mail and VaxNotes systems, 84 of 408 were contributed by the instructors. Detailed quantitative analysis was conducted on two randomly selected weeks of notes, and coded into participation categories and participant role. Instructors' contributions were also analyzed. In the electronic discussions, students selected topics, determined goals, and shared experiences and understanding with peers. The study reveals a promising way of employing an ordinary communications technology to facilitate students' learning. Further empirical research is recommended to verify the note coding schemes and models of analysis. Further studies to establish practical guidelines for incorporating computer mediated tools into classrooms are also recommended. Includes 11 tables with analyzed data on the electronic notes, and a diagram illustrating the pattern of knowledge construction in the electronic discussion. (Contains 42 references.) (SWC)

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Title:

Meaning Negotiation, Knowledge Construction, And Mentoring In A Distance Learning Course

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INTRODUCTION

Technology tools have been used in schools, corporations, and government agencies to extend or enhance both physical and/or cognitive human capabilities in work and study. In education, they have been used to facilitate and revolutionize teaching and learning. Distance learning is one of many educational initiatives that has greatly benefited from the advent of recent technology tools, such as electronic conferencing systems, resource sharing systems, and group access support systems. The relatively low-cost electronic conferencing system is proving to be a powerful and increasingly popular medium--either for totally 'online' courses or for more conventional in-classroom and distance learning courses (Verdejo & Cerri, 1994). Electronic conferencing promotes student-centered learning. That is, it no longer emphasizes the teacher as gospel or the primary source of knowledge. Different kinds of electronic conference software packages provide technical and pedagogical support for organizing and structuring conference topics and message retrieval.

The present study describes how VaxNotes, an electronic conference software, was used at a large midwest University in a graduate distance learning course "Interactive Technologies for Learning". In that course, students' electronic discussions and knowledge construction as well as instructors' methods for organizing the electronic conference in distance learning course were saved and analyzed. The study revealed and discussed patterns of students' electronic discussion and knowledge construction practices. Additionally, this study reviewed and analyzed various ways of organizing the electronic conference and mentoring in this distance learning course. In effect, this study provided insights into how to employ electronic conferencing technology in facilitating teaching and learning by informing teachers of what technology was used in the classroom and how it was used as well.

It is hoped that the study will be informative and will perhaps inspire other instructors to employ social and cognitive learning theories in an electronic conference. The work presented here can be a springboard for other researchers to use social and cognitive learning theories as the theoretical framework for continued research in computer conferencing.

THEORETICAL FRAMEWORK

Vygotsky's learning theory and theories of cognitive and constructive learning provide a helpful theoretical framework for the present study.

The conceptual framework of Vygotsky's theory provides a good basis for understanding learning as a process of social negotiation and collaborative sense making, and mentoring as an effective technique to assist students in collaborative activities and knowledge construction. One of the key concepts in Vygotsky's theory is the zone of proximal development. Vygotsky defined this as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers"(1978, p 86). This definition expresses Vygotsky's notion that what children can do with the assistance of others might be, in some sense, even more indicative of their mental development than what they can do alone (Meichenbaum, et al. 1985). Their achievements in a supportive social environment make the largest contribution to their cognitive development (Fowler & Wheeler, 1995).

A related important concept in Vygotsky's theory is his idea that intellectual development takes place between people before internalization takes place. Vygotsky contended: "Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane and then it appears on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category"(1981). That is, our social and cognitive development occurs when we are interacting with peers and experts. The interactions with peers and experts in the social content and context transform the interpersonal process into the intrapersonal process. Socially displayed values, theories, and ideas are thus internalized in individuals through this transformation.

From this point of view, instruction is most effective when it is in a form of discussions or dialogues wherein learners can interact with peers and adults or mentors who challenge, support, and scaffold their learning. As sociological researchers point out, instruction should take place in a social environment, in which learners use socially mediated and intellectual tools to achieve cognitive development (Rogoff, 1990). Here, the instructor designs learning activities in the zone of proximal development. This zone is neither a property of the child nor of the interpsychological functioning alone, but is jointly determined by the child's level of development and the form of instruction involved. The challenge to educators is to develop forms of instruction so that interpsychological functioning can be structured to maximize the growth of intrapyschological functioning (Wertsch, 1990).

An electronic conference in distance learning courses or regular courses can be viewed as a device through which interactions between learners and instructors can take place. By using the electronic conference, they both can voice their

opinions and reflect on their learning. As indicated, these interactions among learners and instructors increase interpsychological and intrapsychological activities and maximize individual's cognitive growth and development.

The social aspect of learning and intellectual development is one part of the theories guiding the present study. The other part is the view of learning as a constructive process of engaging in self-regulated, constructive, and reflective activities. Quite a few theorists challenged the traditional role of the teacher and the student. They argued that the role of teaching and other instructional media is shifting from one that seeks to maximize the communication of fixed content and skills to one in which students are led to experience the knowledge construction process (Knuth and Cunningham, 1993). From this perspective, students construct interpretations, appreciate multiple perspectives, develop and defend their own positions while recognizing others, and become aware of and able to manipulate the knowledge construction process itself. That is, students are no longer passive recipients of bodies of knowledge, but are actively involved in the knowledge-building process, in which they discuss, elaborate upon concepts, and devise relationships among them, and in which they view multiple perspectives on concepts or issues, and generate their understanding based on prior knowledge and current understanding.

"While the individual learner is the only one who can construct his or her unique understanding of the world, this understanding emerges in a social context" (Cunningham, Duffy & Knuth, p. 25. 1993). We view the electronic conference in the distance learning course as the social context from which individual understanding is emerged. The electronic conference provides a space for students to exchange ideas, discuss issues, and join efforts in searching for solutions to problems. It enables asynchronous collaboration in the distance learning course.

Learning is not only active, constructive and cumulative but also a goal directed process. It is goal oriented in that learning is most likely to be successful if the learner is aware of the goal towards which he or she is working and if the learner holds expectations that are appropriate for attaining the desired outcome (Schuell, 1988). Learning requires learners to engage in collaborative activities and in self-regulated and reflective activities as well. The distance learning course in this study provided such opportunities and experiences for learners. While students were participating in the electronic discussion, they engaged not only in interaction and collaboration with peers, but in such activities as goal-setting, planning, and monitoring as well.

John Dewey once argued that human intelligence and all learning are cultivated through reflective thinking (1933). When individuals examine and test their ideas with a purpose, they are better able to use their knowledge in informed and self-directed ways. The electronic discussion not only enables interaction and collaboration but promotes self-regulated learning activities and reflective activities as well. Reading and responding to peers' and instructors' notes forces students to think, form ideas, and articulate them in a meaningful and sensible way. Reading the peer's and the instructor's thoughts urges students to compare them with their own thoughts and ideas, and to examine their own understanding and interpretations.

The reflective activity in the distance learning course thus involves students' self-appraisals, reflection on the class and on past experience, and re-construction of concepts and ideas. In the reflection process, existing knowledge is re-constructed to yield new perspectives. The essential components of any effective learning are social interactions, reflective activities, constructive activities, and self-regulating learning activities. It is under these theoretical and epistemological beliefs that the current study was conducted. Furthermore, these beliefs are consistent with those reflected in the readings and articles chosen for this graduate distance course.

METHODOLOGY

Setting and subjects

The study was conducted in a 16-week graduate seminar--"Interactive Technologies for Learning"--co-taught by two instructors at a large midwestern University Spring, 1995. The seminar focused on the discussion of "the notion of the computer as an educational tool." It incorporated an assortment of lectures, demonstrations, videos, and small and large group discussion activities as well as few live class discussions with authors of selected readings through CU-SeeMe.

The students in the course were mostly in Masters and Ph. D. programs such as Instructional Systems Technology, Educational Psychology, and Telecommunications. They met for three hours every Monday during the spring semester. Students at two campus were connected via video and audio distance learning technologies, so that they could see each other and their instructors at both ends. Each class period was usually devoted to a variety of activities such as the instructors' summarizing weekly readings, class discussions of readings, and students or instructors demonstrating computer-mediated tools for learning. An average of 80 pages was assigned for each week's reading

Consequently, though each student could voice his/her opinions, understandings and questions about weekly readings during a session of three hours, a thorough discussion of readings and multiple perspectives of readings could not be achieved during the allocated class time. Thus, most of the discussion about weekly readings and sharing of individual understanding took place in the form of computer-mediated communication(CMC). In this case, it was E-mail and VaxNotes. E-mail was the primary communication channel for the first two and half week's discussions. Later class discussions gradually migrated into VaxNotes.

The student electronic discussion consisted of four major components: instructor's introductory questions and reading advice, weekly starter comments, weekly wrapper comments, and participant comments. The instructors designed the starter, the wrapper, and weekly participant roles for the students. Their participation in the electronic discussion was worth 25 percent of the final grade. Students assumed a starter or wrapper role just once during the semester, but were asked to participate in some manner each week.

As a *starter*, a student might: (1) state reactions and questions and make suggestions for the upcoming readings; (2) point out the relationship of an upcoming topic or articles to past lectures or readings; (3) discuss the position of a pioneer in the field; (4) discuss a recent visit to a technology center, exhibit, or conference demonstrating computer tools; (5) attempt to relate student prior learning and discussion to the current week's readings. In effect, the starter role was intended to provide the class with key themes, issues, or questions leading to the upcoming week's readings.

The *wrapper* role, on the other hand, was meant to bring some of the discussed issues and questions to some sense of closure. Summarizing and synthesizing key points and themes was within the wrapper's purview. Therefore, as a wrapper, a student might: (1) react and reflect on any lecture, discussion, or demonstration; (2) restate and reflect on the starter's initial points for that week; (3) point out questions and concerns that have yet to be answered; (4) note any additional related readings; or (5) react to a guest speaker's ideas or a unique class activity.

As a *weekly participant*, one might: (1) participate in the discussion; (2) answer questions and concerns of other participants; (3) question or respond to a peer at another site; or (4) bring to everyone's attention a related conference, issue, newspaper article, or grant proposal.

Data

The data was collected from both E-mail and VaxNotes discussions. A total number of 408 notes were collected from E-mail and VaxNotes. Of these, 84 notes were contributed by the instructors. Quantitative analysis was performed on all the data collected; however, due to the vast amount of data, a qualitative, descriptive, and detailed analysis was conducted on the discussion of only two randomly selected weeks (Week 9 and Week 12).

The collected E-mails and VaxNotes messages were coded into participation categories such as question, reflection, discussion, comment, and answer. Additionally, each student and instructor during the discussion was studied in roles such as contributor, wanderer, seeker, and mentor. Patterns of the student electronic discussion, interaction, and knowledge construction were discussed based on the analysis of participation and role categories. To further complete this teaching and learning picture, the instructors' contributions were analyzed in the way of planning, introductory questions, contributing toward discussions, commenting on students' responses, and guiding students' learning.

Framework for analyzing data

The data analyses disclosed the relationship and the nature of students' and instructors' notes in the electronic conference, thereby providing a better understanding of how students construct new knowledge and understanding, and how electronic conferences can be efficiently organized to facilitate learning. The analyses required not only an understanding of how students contributed to the electronic conference but also a familiarity with the content area to help determine the role of each student, and the evolution and development of an idea or a topic. No previous analytical framework or coding schemes, such as conversation analysis (Schegloff, 1981) or protocol analysis (Ericsson & Simon, 1984), could be readily applied to suit such unique analyses of data.

For the purpose of this study, a specific coding scheme was constructed. The scheme incorporated both Hatano and Inagaki's (1991) theory of group interaction and Graesser and Person's (1994) theory of question analysis. Construction of knowledge through social interaction can be observed in two types of interaction, *horizontal* and *vertical* (Hatano & Inagaki, 1991). According to Hatano and Inagaki, both vertical and horizontal interactions could refer to the interactions among peers. In the *vertical interaction*, some group members will concentrate on looking for the more capable member's desired answers rather than contribute to and construct knowledge. By contrast, in the *horizontal interaction*, members' desires to express their ideas tend to be strong, because no authoritative correct answers are expected

to come immediately. Therefore, the members often express a variety of ideas and participate in the exchange of ideas which are likely to be examined and elaborated in such interaction (Hatano & Inagaki, 1991).

The coding scheme for data analyses consists of participant categories, types of interaction, and note categories (See Table 1 & Table 2). In the participant category, four kinds of student roles were identified, such as contributor, wanderer, seeker, and mentor. Two types of interactions were distinguished. Notes were classified according to meanings as reflective notes, comments, discussions, answers, information sharing notes, scaffolding notes, and questions.

Two main types of questions are detected in the electronic conference. The first, Type I, is information-seeking questions (Graesser & Person, 1994). When a genuine information-seeking question is asked, the questioner is missing information and believes the answerer can supply it (Graesser & Person, p. 108). Van der Meiji (1987) identified several assumptions underlying a genuine information-seeking question: a) the questioner does not know the information asked for in the question; b) the questioner believes that an answer exists; c) the questioner wants to know the answer; and d) the questioner believes that the answer will not be given in absence of the question (Graesser & Person, 1994).

The other, Type II, is discussing questions. Assumptions underlying discussing questions are: a) the questioner can provide some kind of explanation to the question, but he believes that it may not be complete nor most appropriate; b) the questioner understands that there are no existing and ready answers to the question; c) the questioner would like to seek opinions from peers or experts; and d) the questioner intends to start a dialogue among peers rather than ask for answers. Questions here are usually deep-level ones regarding particular research issues but normally without definite answers.

Reflective notes are defined as any reflective thoughts running through participant notes. These can be: a) evaluation of the class and learning; b) self-appraisal of learning and understanding; c) instances of comparing and relating past readings or past experiences to current readings and understanding; and d) instances of self-adjusting learning goals and objectives. The main characteristics of reflection here are evaluation, (self)appraisal, and (self)adjustment.

Comments refer to any non-interrogative statements concerning readings. Examples of comments could be: "I agree (disagree) with...", "The author is right in ... ", "The question raised in the article is very important ...". The main characteristic of comments is students' voicing judgments or opinions.

Answers refer to statements which provide specific information to the Type I question--information-seeking question. These, for instance, may be key quotes, basic facts, procedural knowledge, and stories from one's readings.

Discussion and information-sharing notes refer to general statements relevant to discussion topics. These may include: a) elaboration on discussion topics; b) exchanges of thoughts or ideas on related concepts and issues; c) personal understanding; and d) topic-related discussing questions.

Scaffolding notes refer to those providing guidance or suggestion for discussions or readings. They can be notes from either the instructor or the students.

Table 1. Note Category and Interaction Type

	Note Category	Characteristics and Examples	Interaction - Type
1	Type I Question	Ask for information or requesting an answer "What does hypermedia mean?"	Vertical
2	Type II Question	Inquire, start a dialogue "How can we resolve the control issues such as governing the shared space when using a collaborative tool?"	H
3	Answer	Provide answers to information-seeking questions "Hypermedia means ... "	O
4	Information sharing	Share information "My colleague and I have done a lot of thinking about the nature and effect of simulations .... "	R
5	Discussion	Elaborate, exchange, and express ideas or thoughts "What intrigues me from this week's readings is not how we define a tool, ... but rather how tools change ourselves..."	I Z
6	Comment	Judgmental "I agree with A that Schorr's article was ..."	O N
7	Reflection	Evaluation, self-appraisal of learning "I found the class last night to be completely frustrating yet intellectually stimulating . ... it is what makes me think!"	T A
8	Scaffolding	Provide guidance and suggestions to others "... let us not move our lives in this same 'scripted' direction. Use the tool as an idea generator, a place holder of ideas ... "	L

As indicated, while in vertical interaction, the individual concentrates on looking for desired answers rather than expressing or exchanging opinions. Whereas in the horizontal interaction, students express and exchange views, directly contributing to the discussion and knowledge construction.

Constructive learning is viewed as being active, cumulative, goal-oriented, and constructive (Schuell, 1988). However, this does not mean that all constructive learning proceeds or should proceed according to all of these lines at the same time (Simons, 1993). In reality, it may be that active learning periods and passive ones follow each other, especially for learning over a long period of time. In essence, learners' behaviors change in the process of learning. They could be very active, highly motivated, and reflective at one time but less active, motivated, and reflective at another. To apply this perspective to analyses of the present study, the discussion participant was identified as contributor, wanderer, seeker, and mentor according to the nature and the content of the notes (See Table 2).

Table 2. Participant Category

Participant Category	Involved Categories
Contributor	Categories 1 - 8
Wanderer	Mainly categories 1, 4, and 6
Seeker	Category 1
Mentor	Categories 1 - 8

Each participant in the discussion was viewed as contributor no matter what type of note was contributed. Information-seeking questions, for instance, brought others' attention to questions which might otherwise have been ignored. The following quote was representative of a large number of other participant notes in the electronic discussion.

"The articles this week really made me think about the way people learn, especially the Envisioning Machine article. It is amazing that kids are able to go from not knowing anything about physics and eventually are able to make sense of it without a teacher in front of them telling them what to do. I think the key is that all of us want to make sense out of the world. We are weird from birth with the ability to take previous experiences and build upon them to discover new concepts. The important part here is that the learners did not do it on their own, but in order to make sense of the situation, they had to rely on each other and negotiate an understanding."

The student here expressed an opinion of learning and discussed how children rely on each other and collaboratively make sense of the world around them. By posting this note, the student brought to the class discussion a unique perspective on this learning issue.

Wanderers are the ones who seem to be lost, for at least the time being, in the reading or the discussion. Those notes usually discussed teaching and learning in general rather than specific issues in weekly readings. They reflected a specific learning stage where learners are floundering, re-adjusting themselves, and striving for an understanding of the issue by relating and associating different pieces of information and knowledge. This stage is an important precedent to learning and understanding. The wanderer's notes contribute to the discussion from a different angle; that is, not through elaboration, but through creating perturbation and conflicts in the reader.

Seekers are the ones who feel an information deficit and a need to seek information in order to gain a better or an appropriate understanding of the issue. A seeker, for example, wrote: " I don't understand what they meant by shared space. I read the section more than once, but the idea doesn't want to sink in my mind. Can you help?". The "seeker" here apparently does not have enough knowledge and understanding about the concept--shared space. Without this, the "seeker" could not comprehend the meaning after reading the article.

Mentors are those who when reading participant notes, try to understand the participants' interpretation and knowledge levels and guide them in their reading or help them defend and develop their own ideas and understanding of issues. A mentor in the discussion of Week 12, for instance, said: " Note A commented that the IdeaFisher could constrain one's creative thinking because you are using someone else's opinion of what things might be associated with other things. In fact, every piece of software you use could be considered an interpretive work at some level ... ".

While students and instructors could fall into any of these categories in the electronic conference, the period of time one is in the categories of seeker and wanderer is usually transitional and temporary.

The analysis of this study consisted of close reading of every note and counting note length and the number of notes and contributors. Each note was read and analyzed at the sentence and the paragraph level with a concentration on its meaning. Thus, main ideas of the sentence or the paragraph were listed as points for the discussion. The pattern of the electronic discussion and knowledge construction was generated using these main points and analyzed according to the framework previously discussed. The techniques of writing, grammar, rhetoric, and the like were deemed less pertinent and important to the study and thus were ignored during the analysis. Likewise for the start-up, transitional, and wrap-up words and phrases.

ANALYSES

While a general analysis examined the semester-long discussion, a detailed analysis was conducted on two randomly selected weeks to examine the pattern of electronic discussions and knowledge construction, the role of the instructor and the student, and ways of mentoring used in the electronic conference. The weeks selected and their topics were Week 9--"Science tools for collaboration in a learning community" and Week 12--"Music, art, visualization & animation tools for creativity & critical thinking".

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Table 3. General Analysis for a 15 Week Discussion

Week	Topic	Number of notes	Number of contrib-utors	Average line length	Instructors' notes & percentage
1	Introduction: Trends in computers as cognitive and sociomedia tools	10	7	7.68	5 (50%)
2	Linking tools to learner centered psychological principles	17	13	20.5	3 (17%)
3	Learner centered design	16	14	40.9	6 (37%)
4	Multimedia composition and knowledge construction	35	18	41.06	6 (17%)
5	Writing tools for idea generation and cognitive enhancement	24	16	54.6	5 (24%)
6	Distance writing collaboration tools & computer-mediated communication	24	16	32.14	7 (29%)
7	Internet, Mosaic, WWW, & other information systems	29	16	30.2	6 (20%)
8	Science tools for collaboration in learning community	40	18	30.8	4 (10%)
9	Science tools for conducting inquiry	32	15	29.8	3 (9%)
10	Math tools for problem solving and problem representation	31	15	35.35	10 (31%)
11	Computer programming & CAD systems for designing knowledge	32	19	39.78	7 (21%)
12	Music, art, visualization & animation tools for creativity & critical thinking	23	17	36.4	2 (9%)
13	Virtual reality, intelligent tools, & other dreams of reality	32	19	37.09	6 (18%)
14	Student self selection Week	21	18	28.5	2 (9%)
15	Cognitive and sociomedia tools revisited	14	12	44	1 (7%)
*	Other creative reflections	8	8	18.75	0
**	Tool taxonomy presentation (one of the assignments)	20	12	16.35	8 (40%)
Total /Aver-age		408 / 27	14	32 lines	

* "Other creative reflections" is not a weekly discussion topic, but notes contributed by students throughout the semester about their reflective thoughts.

** Tool taxonomy presentation is one of the class assignments. Students put their discussion notes about the assignment under this topic exclusively.

General analysis

Quality. Fifteen weeks' electronic discussions generated a total number of 408 notes (See Table 3) from 17 discussion topics. The average number of notes contributed each week was 27 . The note length ranged from 8 lines in the first week to 55 lines in the fifth week. The average note length across the 17 topics was approximately 32 lines. Each line was roughly 10 words, making an average note length of approximately 320 words. Of all the discussions in 15 weeks, only the first week had an average length of eight lines. The rest all exceeded an average of 20 lines. Three hundred and twenty words could fill one page and 550 words could be printed on almost two pages double spaced. The quality of the electronic conference is closely, though relatively, related to its quantity or note length. Clearly, students here were not simply raising information-seeking questions, but were really writing thoughtful reflections, discussions, and comments.

Students' involvement. The number of contributors was steady across all the discussion topics and in appropriate proportion with the number of notes in each week given the number of students taking the class. The smallest number of contributors was 7 and the largest was 19 in the class of twenty-two students. Over 73% of the students participated in the electronic discussion each week, with a participation rate ranging from 35% in the first week and 95% in the eleventh week. If we excluded the first week, when students were starting to use the electronic distribution list for this class, the participation rate would be even higher. Clearly, the discussion space was not dominated by a few students, nor was it swamped with socializing statements, greetings, or information-seeking questions which might be used to earn a participation grade for this class. As indicated above, students mostly posted thought-provoking questions, discussions, and reflections.

Instructors' involvement. Of the total number of notes, 86 notes were contributed by the instructors and accounted for an average of 20%. The percentage ranged from 7% in Week 15 to 50% in Week 1. Scaffolding was high at the beginning of the semester. For instance, in the first week, the instructors' notes accounted for half of the class notes. Most of these notes were to suggest discussion parameters, call for students' participation, and ensure that the E-mail distribution list worked and students responded to it. As the semester moved on, instructors' notes gradually reduced to around 20% with the exception of Week 3 and Week 6 in which the instructors' notes reached over 30%. The discussion topic of Week 3--learner-centered design--drew interest from both students and instructors. The discussion topic in Week 6--writing tools for idea generation and cognitive enhancement--was one of the instructors' special interest area, where he had vast research experiences. In that week's discussion, he shared his expertise and guided students in understanding the use of computer tools to help generate ideas and enhance cognitive development.

Specific analysis

Starter Notes. Detailed data analyses focused on starter, wrapper, instructor, and student participant notes, on specific discussion topics, and any other notes posted in Week 9 and Week 12*. For our analyses, main ideas of each note were summarized, synthesized, and listed in tables. Each note reflected each individual's unique understanding and represented individual's unique contribution to the discussion. The starter's note, to some extent, led a week's discussion. For example, the starter of Week 9 wrote:

> " I think one of the issues we need to address is relevancy. I found it a lot easier to appreciate the role of Sherlock I (Lajoie's article) and the Medical Center program (Anderson's article) as an instructional aid, than I did when I read about Bio-World (Lajoie's article) or the Envisioning Machine (Teasley's article). Both Sherlock I and Medical World have a high degree of relevance to their users, who desire to benefit from using these

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* Assigned articles for Week 9 are: 1) Constructing a joint problem space: the computer as a tool for sharing knowledge; 2) Computer environment as cognitive tools for enhancing learning; 3) Medical center: a module hypermedia approach to problem design; 4)Video labs: tools for scientific investigation; and 5) Wireless coyote: a computer-supported field trip.

Assigned articles for Week 12 are: 1) Socratic approach to use computers with at-risk students; 2) Visual languages for cooperation: a performing medium approach to systems for cooperative work; 3) Prototyping multimedia: lessons from the visual computing group at Project Athena Center for Educational Computing Initiative; and 4) Programs that help you think creatively and plan effectively.

programs. Granted the Medical Center program and the Envisioning Machine can promote problem solving, but is problem solving useful or always possible in the absence of relevancy to the user?"

The starter here raised and discussed the issue of relevancy in using tools. The issue was then picked up, discussed, and commented on by six other individuals during Week 9 (See Table 4).

Table 4. Discussion on the Issue of Relevancy in Using Tools during Week 9

Participant Category	Note	Main Ideas	Note Category
C	N. 1**	Discuss the issue of relevancy in using tools	Discussion
C	N. 5	Discuss relevancy issue raised in Note 1	Discussion
C	N. 6	Discuss relevancy issue (Note 1)	Discussion
C	N. 7	Comment on relevancy in applying tools	Comment
C	N. 13	Discuss the relevancy issue (citing three comments from the previous notes) and suggest that relevancy is related to knowledge transfer, far and near.	Discussion
C	N. 15	Reflect on the issue of relevancy	Reflection

(C= contributor; W= wanderer; S= seeker; and M= mentor)

In both Week 9 and Week 12, students tended to carefully read the starter's note and answer the questions or discuss issues raised. The starter of Week 12 discussed visuals used in daily life and education, and raised a number of discussing questions about weekly readings. He wrote: "The art or visual has been disregarded in education for a long time. Now, we recognize that the information age is multidimensional and the computer is a way for us to grasp the enormous amount of usable information. We see computers as new ways of seeing. Some questions rise from here: How do we conceptualize with vision? How does the use of computational visual affect learner's cognitive development?". Once again, the starter's note initiated a heated discussion on visualization and learning in Week 12 (See Table 5).

Table 5. Discussion on Visualization and Learning during Week 12

Participant Category	Note	Main Ideas	Note Category
C	N. 1	Discuss the number of visuals used in daily life and old saying --picture is worthy a thousand words Discuss that visuals have been neglected in education Raise inquiring questions (1-5)	Discussion Type II Qs
C/M	N. 5	Comment on the blackboards in the halls of the Chemistry building and lack of it in Education building Share experience with the class on visualization	Comment Information Sharing
C	N. 6	Discuss Latin's article (creativity -- people use each other's ideas to develop a better end product) and raise questions concerning working with group Reflect on personal experience working in groups	Discussion Reflection
C/M	N. 7	Discuss Vmacs	Discussion

** The note number signifies the order in which the note was contributed. The number uniquely identified each note but does not carry any other meaning.

Table 5. (continued)

Participant Category	Note	Main Ideas	Note Category
C	N. 10	Discuss visualization	Discussion
C	N. 18	Summarize different comments on visualization	Discussion
C/M	N. 19	Response to one previous question--visualization seems to be rising in importance	Answer Scaffolding
C/M	N. 22	Share experience on how teachers and students collaborate in teaching and learning Discuss visualization	Discussion Type II Qs

Table 5 lists notes from eight students during Week 12. These notes, though falling into different categories such as comment, discussion, information-sharing, and scaffolding, all centered around the discussion of how visualization being used in daily life as well as in instruction. Quite a few referred to the blackboards in the chemistry building on campus and commented that the blackboard served as a space for visualization and for exchanging ideas as well. One mentor here related visualization to tools and learning, and reiterated the importance of visualization in learning. Mentors acquainted peers with some real world practices for using visualization in teaching and learning.

Wrapper Notes. The wrap-up for the weekly discussion did not demonstrate its expected value to synthesize the groups' understanding of the readings. In most weeks, the wrapper simply expressed his/her personal feelings and summarized the individual understanding of topics discussed. For example, the wrapper for Week 9 wrote: "I particularly enjoyed the readings for this week. I am sure that part of the reason is that they were concerned with subject matter that I am familiar with, so my ability to envision the tools discussed was enhanced. .. I agree with student B that the thrust of Lajoie's article are the 4 tools that assist learners to accomplish cognitive tasks." In some other weeks, the wrapper technically summarized what each student and instructor contributed without pulling them together or synthesizing these ideas. For example, the wrapper for Week 12 wrote:"... Student C raised a question of 'the chalk board in the Chemistry Building' which a couple of people replied that they will agree with this idea--gathering information from more than one source...". Wrappers read discussion notes, reflected on them, but often offered few insights or summaries.

Instructor Notes. During Week 9, the instructors contributed three notes which accounted for 9% of the total. Three notes involved general comments to the class and suggestions for future learning. The instructor reflected on the history of computing and tools evolution, commented on tools and theories guiding the development of tools, and encouraged students to take part in the role play (See Table 8). He discussed different types of tools related to five levels of learning as well as four different types of cognitive tools identified in the readings. Additionally, he pointed to his own experiences to guide students in understanding the concept of cognitive tools. For instance, he wrote: "She (Lajoie) says that there are 4 types of cognitive tools that can be identified by the functions that they serve... they support my memory and strategic thinking, give me the facts so I don't have to waste my time, enable me to engage in new activities, and get me to test and explore new things...". Such restatement and simplification of the readings were typically offered by the instructor after the weekly starter's comment and students' wandering or queries. According to the instructor, this was useful and necessary.

Table 6. The Instructor's Notes during Week 9

Participant Category	Note	Main Ideas	Note Category
C/M	N. 9	Reflect on the history of computing, Reflect on tools evolution, Encourage debate and role play	Reflection Suggestion
C/M	N. 14	Comment on surfing the net and the related jobs, Comment on tools vs. theories	Comment Scaffolding
C/M	N. 24	Comment on learning in the class, Share information about other available materials related to the class, Suggest students' writing proposals for conferences, Comment on the previous class (agree with Note 22), Discuss different kinds of tools and levels of learning, Discuss four types of cognitive tools identified in one reading	Scaffolding Comment Suggestion Discussion Information Sharing

During Week 12, the instructor contributed two notes, comprising 9% of the total. The instructor commented on the metaphor used by one student to describe thinking and clarified that we are emphasizing process skills in education today. He challenged students with such questions as whether computers really can teach such process skills. Next, the instructor responded to a participant note about how computer software can assist cognitive development. He further illustrated how a tool, e.g. Writing Partner, can help people think and plan creatively. Using his own experience and understanding, the instructor guided students' learning by reading their notes and explaining how tools can be used to help people think and plan. In reflection, the instructor later said that he was always focusing on assisting students in their understanding of the issue.

Topic Discussions for Week 9. The topic of collaboration brought together five students to exchange ideas and opinions. They engaged in a lively debate about differences between cooperation and collaboration and examined the relationship between the information explosion and collaboration. One student wrote: "They (authors) make a distinction between collaborative and cooperative problem solving that I hadn't given much prior thought to. Cooperative meant that there was a division of labor in the problem-solving but collaborative meant that everyone was engaged in trying to find a solution." Another student related the information explosion to collaborative learners and workers: "Because of knowledge explosion, ... they (students) must learn to be collaborators, because being able to access the information doesn't mean knowing how to apply it or if it is the right information to apply."

The discussion in Week 9 well illustrated Dewey's point that reflection is a way of learning. Through thirteen notes in Week 9 (See Table 7) the students engaged in reflective activities on the class, its readings, ways of learning, and sharing information, and comments on the role play activity.

Table 7. Reflective Thoughts in the Discussion during Week 9

Participant Category	Note	Main Ideas	Note Category
C	N. 7	Comment on learning in general	Reflection
C	N. 11	Discuss the reading while playing a role	Reflection
C/M	N. 14	Comment on surfing the net and the related jobs	Reflection
C	N. 15	Comment -- can't play a role	Reflection
C/M	N. 9	Encourage debate and role play	Suggestion

Table 7. (continued)

Participant Category	Note	Main Ideas	Note Category
C	N. 19	Reflect on readings in general	Reflection
S	N. 20	Question about technical problems in VaxNotes	Type I Q.
C	N. 23	Reflect on the class (completely frustrating yet intellectually stimulating) Comment on the instructors' summaries and comments made in the previous class Comment on the week's reading (enjoy because of the content familiarity)	Reflection Comment Comment
C/M	N. 24	Comment on learning in the class Comment on the previous class (agree with Note 22)	Reflection
C	N. 25	Reflect on the week's reading and learning	Reflection
C	N. 28	Share experience of young children learning computer games Share experience in high school science class and comment on the science class with Education technology tools (would enjoy more if tools were available)	Reflection Discussion
C	N. 12	Share information on a job related to Education technology	Information Sharing
C	N. 16	Reflect on the class and what has been learned	Reflection

Almost all of these reflections on learning contributed to the discussion, and some students acted as mentors at the same time. Further, they played assigned roles (e.g. optimist, watchdog, speculator, and questioner). Role play activities encouraged other students to be actively involved in the discussion.

Discussion of general learning and thinking skills was another common topic during Week 9 (See Table 8), when about ten individuals discussed these and other related issues.

Table 8. Discussion on General Learning and Thinking Skills during Week 9

Participant Category	Note	Main Ideas	Note Category
C	N. 1	Raise questions about the validity of two studies in weekly readings	Type II Q
C/M	N. 9	Reflect on the history of computing	Reflection
C/W	N. 13	Comment on structured learning vs. unstructured learning	Comment
C/M	N. 14	Comment on tools vs. theories	Comment
C/W	N. 16	Discuss constructivism and tools Raise questions about constructivism	Discussion Type II Q.
C/W	N. 22	Discuss knowledge transfer	Discussion

Table 8. (continued)

Participant Category	Note	Main deas	Note Category
C	N. 25	Discuss student learning, problem solving, and critical thinking skills	Discussion
C	N. 26	Discuss and raise questions about the nature of learning	Discussion
C	N. 28	Discuss floundering in learning (through playing computer games)	Discussion
C	N. 27	Comment on problem-solver (reply to the previous note)	Comment

They interacted as contributors, mentors, and sometimes wanderers. One of the mentors reviewed the history of computing, providing some background knowledge for a better understanding of how tools evolved to assist learning. The mentor also highlighted the relation and nature of tools and theories, thus supporting students in their understanding of how theories are being used to guide the design of tools. Wanderers contributed to the discussion through the analysis of structured and unstructured learning, constructivism, and tools. They wondered whether these issues related to collaboration, virtual field trips, and others. If they were interconnected, the wanderers had yet to discover these associations. Wandering did not hinder their learning. In fact wandering helped others learn, because the wanderers' notes added fuel to the discussion, created cognitive conflicts, and urged the reader to think. As Piaget would contend, their queries caused other participants to experience disequilibrium and cognitive dissonance which needed to be resolved through additional reflection, discussion, and negotiation.

The following paragraph is a good example of a wandering note in Week 9. It said: "Transfer is important and depth is important. Students have to have opportunities to explore a concept in depth and make transfer from that depth. I think it's the teacher's job to stir that curiosity and that's when the learning becomes relevant, when from a constructionist's viewpoint, you start from the child's prior knowledge. From there you guide them to exploration and transfer and application." This note discussed very generally learning, critical thinking skills, and knowledge transfer without giving or providing any specific references to weekly readings, but instead, it drew heavily from experiences. This note added much food for thought in participant discussions.

Topic Discussions for Week 12. Several major topics of discussion emerged from the discussion of Week 12. They were reflective activities, the issue of using computers with at-risk students, and the issue of software programs that help people think and plan. Four individuals in Week 12 reflected on this distance learning course and the weekly readings. For example, one student wrote: "Once again, I'm excited about the readings for this week. In the beginning of the semester I was intrigued with the technology of education and was at a point of believing that using technology could save our educational system. I really am understanding that technology alone really has no bearing on how someone is able to learn better. It's a very complicated process that I've become more aware of..." Another student wrote: "I would like to say that I am REALLY getting the feeling of this distance thing. As you may not be aware, I am in Syracuse, New York for the rest of the semester .... I won't be in class, but I will be participating in the class discussion in VaxNotes. I can't think of a better class where this situation would be more suitable." (This student was in the hospital during the last month of the semester.) Both students revealed their true feelings towards the course. They started from totally divergent routes but came to a converging point. That is, they felt they had learned a lot from reading and participating in the weekly electronic discussion.

Table 9. Discussion on the Use of Computer Tools with At-Risk Students During Week 12

Participant Category	Note	Main Ideas	Note Category
C	N. 1	Discuss Pogrow's article and raise 3 discussing questions about at risk students	Discussion Type II Qs
C/M	N. 2	Discuss Pogrow's article and argue that the issue is teaching problem- solving skill in general	Discussion
C	N. 3	Share colleague's opinion on simulation	Information Sharing

Table 9. (continued)

Participant Category	Note	Main Ideas	Note Category
C/M	N. 5	Discuss Pogrow's article, agreeing with most ideas except "software as instructional objects...	Discussion
C	N. 6	Discuss Pogrow's article and the approach (both agree and disagree)	Discussion
C/M	N. 7	Discuss Pogrow's article -- drama heightens curiosity and motivation and promotes the emotional engagement that deepens learning.	Discussion
C	N. 8	Comment on Pogrow's article and agree with the starter Disagree with the author on at-risk students learning issue	Comment Discussion
C/M	N. 9	Agree with one previous note -- "general problem solving skills"	Comment
C/M	N. 12	Share experiences working with at-risk students Answer one question from the starter -- "when do we let at-risk students back into the normal classroom?"	Information Sharing Answer
C	N. 16	Discuss Pogrow's article -- 1) how instructors use software; 2) software and tools are not answers to education problems; 3) creative use of tools	Discussion
C	N. 17	Discuss the readings -- drama, visualization, creativity	Comment
C	N. 18	Summarize different comments on Pogrow's article	Discussion
C	N. 20	Discuss Pogrow -- "sophistication of the learning produced by technology, depends on the sophistication of the conversation surrounding its use, not the sophistication of the technology." Discuss Pogrow's emphasis on meta-cognition	Discussion
C/M	N. 22	Discuss meta-cognition Discuss at-risk students -- "at some time/different time we are all "at risk".	Discussion Type II Qs

During Week 12, fourteen individuals engaged in a lively sub-discussion about computers being used with at-risk students. They shared information and personal experiences regarding working with at-risk students, and discussed the author's approach to at-risk students. Some answered an information seeking question. Some analyzed the nature of software used with at-risk students and problems with at-risk students. Others challenged the author's approach to at-risk students and the class by saying that "... at some time/different time we are all 'at risk'." Finally, some mentors suggested that other students should think about teaching general problem-solving skills with at-risk students because problem-solving skills are essential to all learners.

Table 10. Discussion on Software That Helps People Think Creatively and Plan Effectively during Week 12

Participant Category	Note	Main Ideas	Note Category
C	N. 1	Discuss Schorr's article and raise 4 questions	Discussion Type II Qs
C/M	N. 2	Discuss Schorr's article, commenting that IdeaFisher would limit creativity more than it could increase it. ... Inspiration allows for more creativity...	Discussion
C	N. 3	Discuss IdeaFisher and argue that every piece of software could be an interpretive work at some level.	Discussion
C	N. 6	Provide answer to one of the starter's question -- "do we need a computer to develop these types of thinking strategies?"	Discussion Answer
C	N. 8	Comment on Schorr's article, enjoying Inspiration	Comment
C/M	N. 9	Discuss Schorr's article from special education point of view Agree with one previous note -- "the effect of the IdeaFisher lies in the inspiration created by effective brainstorming"	Discussion Comment
C	N. 16	Discuss Schorr's article, Inspiration, and Widget	Discussion
C	N. 17	Discuss Schorr's article and agree with the starter (article carries a sale pitch) but personally like software help create ideas	Comment
C/M	N. 19	Discuss Writing Partner	Discussion Scaffolding

About 10 students in Week 12 engaged in a discussion of tools that help people think creatively and plan effectively. The discussion revealed individual opinions as well as a common thread--how can tools help people think creatively and plan. For example, one student wrote: " I thought that IdeaFisher would limit creativity more than increase it. Doesn't this tend to destroy our own creativity and turn us into lazy couch potatoes?". Another student voiced the opposite opinion: "You use this word (here it refers to 'potato') as a springboard to idea generation. This method sounds similar to the word list in IdeaFisher. It really doesn't limit you in terms of creative thinking any less than brainstorming. In fact, it opens you up because it forces you to find a way to use a word like 'potato' to generate ideas about a problem you'd like to solve."

One student said: "I thought that Inspiration allowed for more creativity since the tool did not prod or lead the learner." Another student echoed: "I believe that everyone is in need of such a program--Inspiration. Everybody would like to find some sort of help when it comes to arranging ideas. The visual presentation of one's thoughts, rearranging them in order to create his/her own ideas, changing relationships and so forth makes this tool indeed impressive in my view."

Opinions on computer programs that help people think creatively and plan effectively were quite diverse. The notes demonstrated personal preferences for certain programs and also revealed both excitement and doubts about tools that can help people think and plan. To further assist students' discussion about tools and understanding of how they worked, some of these tools were later demonstrated in class.

Summary of Discussions in Week 9 and 12. The analysis showed that four major discussion topics emerged from the readings and were discussed at length during Week 9. They were: 1) general discussion on the nature of learning, critical thinking skills, problem solving skills, etc.; 2) discussion of tools for collaborative learning; 3) the issue of relevancy in the use of computers; and 4) reflections on the class and weekly readings. In Week 12, four major themes or threads ran through the discussion: 1) general discussion on thinking skills and technological tools for learning; 2) reflections on the class, readings and learning; 3) discussion of tools, such as IdeaFisher, Inspiration, and Writing Partner that help people think creatively and plan effectively; and 4) discussion of tools and their uses in special education.

The analysis of two weeks' discussions revealed that almost all students were contributors and the instructors were mentors during electronic discussions. The notes were mostly in the categories of discussion, comment, reflection, information sharing, and scaffolding (See Table 11). There were only two type I questions (e.g. What does it mean by "share space"?). The interaction type during the two weeks' discussions was predominantly horizontal.

Table 11. Summary of Note Category, Participate Category, and Interaction Type in Week 9 and Week 12

Note/Participation Category *	Week 9	Week 12	Interaction Type
Type I question	1	1	Vertical
Type II question	4	10	H
Discussion	23	30	O
Answer	0	4	R
Information sharing	2	4	I
Comment	16	14	Z
Reflection	6	2	O
Scaffolding	4	8	N
Contributor	46	43	T
Wanderer	1	4	A
Mentor	22	8	L
Seeker	0	1	Vertical

RESULTS AND DISCUSSION

Patterns of Electronic Discussion

The analysis has shown some interesting patterns in the discussion. First, the electronic discussion usually centered around some major themes emerging from the weekly readings. For example, in Week 9, six notes discussed cognitive tools and the relevancy of tools used in learning. However, the analysis has also shown that having one discussion topic covered by a group of students' notes does not eliminate the divergence and diversity of the discussion. That is, though each note was discussing the same topic, each perspective was quite idiosyncratic and based on the individual's understanding and experiences. To illustrate this point, consider Note 5 and Note 6 in Week 9. Note 5 was responding to Note 1 and discussed the issue of tools relevancy and so was Note 6. However, Note 5 wrote:

> "Anderson's article on Medical Center gives us the notion of how learning is facilitated by higher order of thinking. The issue that Student A brought forward regarding the concept of transferability of information and relevancy is good. In order for the software to be relevant, it has to set goals. One of the goals in designing Medical Center is to give learners the opportunity to build a schema and relate content knowledge to its application in clinical problem solving."

Note 6 wrote:

> "I think relevancy is what the teacher's role is and also how teachers make the specific tools relevant to their course and learning in general. The process of problem solving is a very important goal in any course (just look at the Indiana standards for public education). I admit the context that the Medical Center program and the Envisioning Machine is not relevant to every subject, but the process of problem solving that these individual subjects teach can be applied to all areas."

* Most notes comprised of several paragraphs and each paragraph was usually devoted to the discussion, comment, and reflection of one idea. Thus, a note can fall into several categories.

The convergence on the major discussion themes did not limit the depth of discussion or the understanding; on the contrary, it brought multiple perspectives to the topic under discussion, thereby providing an extremely rich context for students to construct their individual understanding of the issue.

Secondly, this electronic media supported both the vertical and the horizontal interactions. The participants were at some time equal peers, but other times a few peers acted as guides or mentors for other students' learning. For example, one student in Week 6 wrote:

> "We all seem to be concerned with what technology will *do* to us. Will it improve our thought processes? Will it stunt our creativity? Will it augment or hinder our collaboration? I think there's a danger in giving so much agency to technology. We have to remember where tools come from. They come from our minds. So, tools might be catalysts for improvement of our thought processes, but the agent of change is ourselves."

This student's note reminded the class of a very important idea that tools should be extensions of ourselves, not replacements of ourselves or agents to direct our relationships to learners. We should bear this in mind when we incorporate tools into instruction. Notes like this may have contributed more to the discussion due to their meaning and importance. Accordingly, these students contributed more to that particular discussion topic than to others. Across the weekly discussion, there were participants who raised questions and asked for answers and others who actively shared, exchanged, and constructed new ideas and concepts. Both types of interaction in the discussion were conducive to knowledge construction.

Many researchers (Rogoff, 1990; Wertsch, 1985) influenced by Vygotsky have studied vertical interaction (represented by adult-child interaction). A current learning model, apprenticeship (Collins, Brown, & Newman, 1989) is also concerned with interaction that is vertical in nature; however, other researchers argue that the construction of knowledge through social interaction can be observed much more often in horizontal interaction (peer interaction) (Hatano & Inagaki, 1991). We observed the same phenomena in the distance learning course. The horizontal interaction appeared much more often than the vertical interaction. The role each member assumed was not fixed or permanent, but could be switched and interchanged with ease. The interaction in the discussion moved naturally and smoothly on the interaction continuum rather than jumping from one end to the other. That is, the vertical-horizontal interaction can be seen as a continuum rather than a dichotomy (Hatano & Inagaki, 1991).

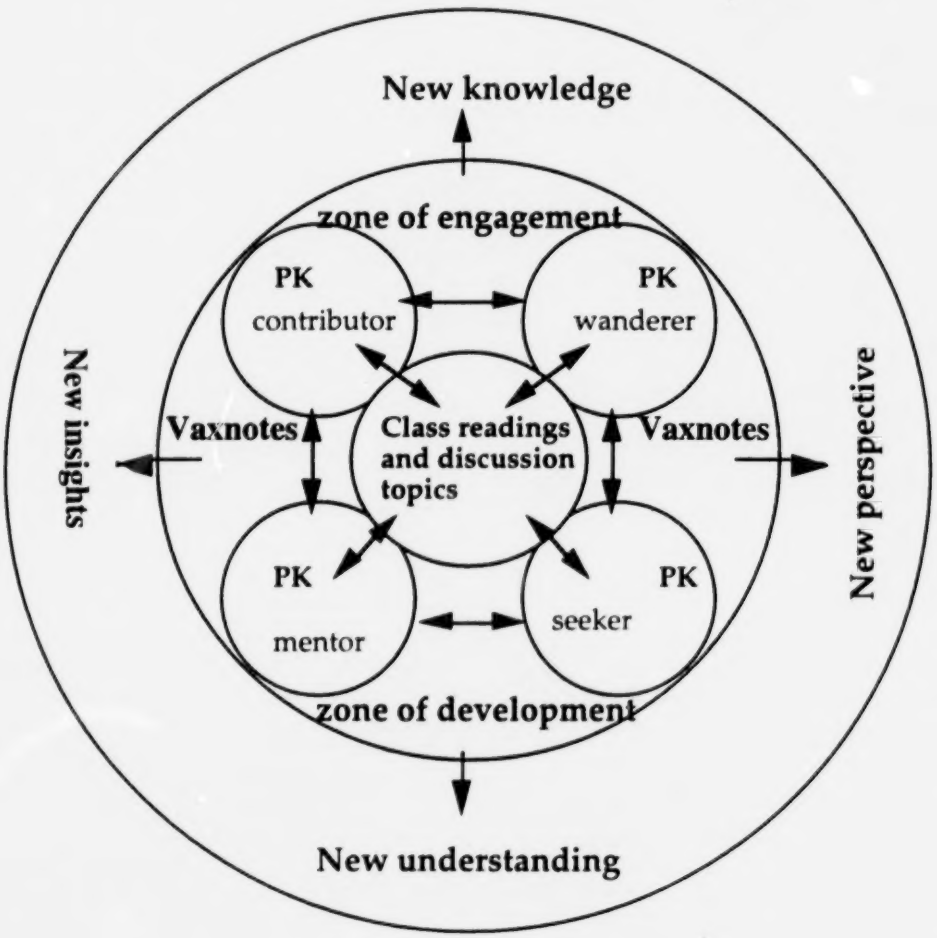
Third, the electronic discussion was apparent within everyone's zone of engagement, therefore everyone was engaged in the discussion, rather than just a few students. As the analysis has shown, the number of contributors was in appropriate proportion to the number of notes each week. Most students contributed once or twice each week. Few students contributed more than twice. Peers' thoughts and notes usually created cognitive conflicts or perturbation in the students and urged them to think and to act. Therefore, VaxNotes provided a space for every student to engage in thinking, acting, expressing ideas, and interacting with peers. Moreover, VaxNotes served as an excellent place for them to work within their zone of proximal development (ZPD) with the assistance from peers and instructors. While working within their own ZPD with the help of the instructors and peers, the students settled many cognitive conflicts and perturbations, thereby maximizing cognitive growth and development.

Pattern of knowledge construction in the electronic discussion

The electronic discussion in VaxNotes is viewed as the zone of engagement and development (See Figure 1) in which every member of the class can participate, express or exchange views, and actively engage in constructing a better understanding of issues based on his prior knowledge and current understanding.

Figure 1

Pattern of knowledge construction in the electronic discussion



Note:

The core (inner circle) is the location of discussion topics .

The shaded circle (middle circle) contains the zones of engagement and development.

The white circle (outer circle) is where students construct new knowledge, understanding, insights, and perspectives.

The participant category circle is the embedded white circle with the abbreivation of PK (Prior knowledge).

In Figure 1, the construction of knowledge starts from the core, that is, the inner circle--weekly discussion topics and readings. Surrounding the inner circle is the discussion space (the shaded middle circle)--the zone of engagement and development where each individual was involved. After numerous trips between the inner circle and the middle circle, and various interactions with equal and superior peers and instructors, the student finally arrives at the outer circle wherein he/she constructs new knowledge and understanding. The assistance from instructors and peers and the interaction among them are crucial to learning and knowledge construction (Gallimore & Tharp, 1990). The constant trips and interactive relationships are represented by bi-directional arrows used between the inner circle and the middle circle and among categories of participants within the shaded middle circle. In the electronic discussion, the student and the instructor may assume the roles of contributor, wanderer, information-seeker, and mentor. As indicated, the role of each individual is by no means permanent or exclusive. The student can assume several different roles or shift roles in one electronic note. The bi-directional arrows between each role depicts the interchangeable and interactive nature of a role.

According to this model, a student reads weekly assignments, discusses them in the electronic space, and reads other students' notes. When moving back and forth between the inner circle and the middle circle--from reading and discussing, the student brings prior knowledge and experience. The activities of reading and discussing are highly integrated so that the student may read one article at one moment and in the next minute may post thoughts in the electronic conference or read notes from other students. Embedded in these activities are a series of other learning activities such as sharing information, requesting answers, reflecting, and commenting. Thus, while engaging in such activities, the student also is assuming the responsibility to plan, monitor, motivate, and regulate learning. Exercising such metacognitive skills has received increasing attention by educators and researchers (Paris & Winograd, 1990).

The formation of a plan, goal-setting, and other activities are socially and cognitively regulated by the interaction with peers and instructors. From Vygotsky's (1985) point of view, the student is moving between the interpersonal plane (social plane) and the intrapersonal plane (psychological plane) in the electronic discussion, because activities such as planning, monitoring, and self-regulating have to happen on both planes. In other words, the individual's cognitive development is not attributed to the individual alone but has its origins in social groups such as the large and small discussion groups in our electronic discussions. The student has to adjust and re-define learning activities through interactions with peers and instructors. In our case, the notes contributed by each individual urge other students to re-examine their learning goals and objectives. These notes in the discussion also create cognitive conflicts for any future reader. In other words, social interaction serves as a stimulus for individual cognitive growth.

Though knowledge construction and acquisition share the same pattern among students in the electronic discussion, differences do exist even among those who are actively involved in the same discussion. The acquisition of new knowledge and understanding will not be equal across the board. It depends on the amount of activities in which the individual is engaged in, the effort invested, and on his or her prior knowledge. While the major pattern of knowledge construction in the electronic conference is similar (i.e. starting from the inner circle and arriving at the outer circle as illustrated in Figure 1), the sub-process each individual engages in may differ. Two possible processes could be identified in the knowledge construction in the electronic discussion: a) individual construction of knowledge motivated, influenced, and facilitated by the discussion and the interaction with peers; and b) assimilation of information proposed by others with some individual editing. The more active students are, the more likely they are to go through the first process and the less active students engage in the second process.

Electronic Discussion Organization

As indicated earlier, the organization of the electronic discussion consists of four major components: the starter, the wrapper, the introductory questions and advice from the instructor, and participant comments. A good starter usually pointed to a few major discussion themes for a weekly discussion. However, using a wrapper for each week did not reveal many educational advantages. In fact, most students simply ignored the wrapper. The reason may be that the summary of one's learning can be quite individual. When a student has gone through a week's discussion, he/she needs to think or reflect himself/herself about what and how is learned. There will be little or probably no commonality in the way each individual summarizes or concludes at the end of a weekly discussion. No individual's wrap-up can be so comprehensive and exhaustive as to include and represent the ideas of the entire class. From this perspective, the role of wrapper does not function as successfully in the electronic discussion as is expected.

The instructor's introductory questions served as exemplary guides to the discussion. However, the students usually did not set the discussion around those questions, nor did the instructors endeavor to lead the discussion around the questions. The reason for this could be that: 1) students do not see any close relationships between the readings and the questions posted; 2) the students feel more restricted in the discussion if they follow the questions; 3) the questions

are too broad to focus on; and 4) the instructors do not have the adequate mechanisms to lead the discussion towards the questions. Questions in Week 7 and Week 10 could explain one point here. The instructor posed such introductory questions for Week 7: "Why is information access so important? Can we teach search skills?" For the discussion in Week 10, one introductory questions was: "Is there any difference between tools, tutors, and multimedia word problems?". These questions were very broad and hard to focus on given no further guidance.

Though the organization of the electronic conference was conducive to discussions and effective in facilitating learning, much could be improved. First of all, after assigning the role of the starter and the wrapper, mechanisms could be invented to constantly monitor the implementation of roles and to revise them if necessary. Secondly, in addition to the role of the starter and the wrapper for the weekly discussion, volunteer students could be recruited each week to serve as extra facilitators and mentors during the discussion. The instructors could have paired up some advanced students with new students and let them serve as mentors to the new students. When in a pair or a small group, advanced students could more accurately diagnose the new students' skill and understanding levels, thereby providing them with appropriate information, sharing experiences with them, and helping them better understand the issues. The advanced students could serve as a bridge enhancing the link between instructors and the new students. While these students are still novices compared to the instructor, they are perceived as experts by the new students. They could play dual roles--help themselves as well as fellow students to learn. If the advanced students in the class were taking dual roles, more of students' learning could be guided and consequently their involvement in the discussion could be more meaningful, and their learning more successful. Lastly, the introductory questions for the discussion could be more issue-based to give students more latitude in developing their own ideas and thoughts. Meanwhile, it could draw them to central issues and thus be easy for the instructors' guiding and scaffolding.

Roles of Students and Instructors

Students' role. The use of VaxNotes and its discussion has reconfigured the role of the student and the instructor in this distance learning course. Students in this class were actively involved in their own learning through such activities as planning, self monitoring, and self-regulating. What the instructor provides here was reading materials, insights, and an electronic conferencing tool. It was left to the students to decide how to take advantage of the tool (i.e., VaxNotes), the electronic resources, and assistance from the instructors. Students decided how to participate in the discussion, how to learn, and what to learn. Learning was centered around students and thus they had more control over their own learning. Some students enjoyed using VaxNotes as a tool to engage in the discussion because they believe the action of writing down their ideas makes them think and reason more deeply and clearly. Our survey indicated that students believe that through this electronic conferencing they learn more about the subjects and about the peers; everyone is participating, even the most shy students whose perspectives and voices are usually absent in face to face discussion. For example, one student said: "Surely, using VaxNotes or news groups or even email has a big advantage, that is, for shy and foreign students whose first language is not English, this is a very good place to express their opinion."

Instructors' role. The role of the instructor has been reconfigured just as the role of the student has been. The instructor is no longer a knowledge dispenser or a lecturer who preaches without listening to students' input, understanding, and interpretation of the readings. Instead, in this course the instructor was the mentor and the facilitator of students' learning. The instructor read students' notes, interacted with them, assessed their understanding, and thus provided guidance for their understanding and learning. For example, in Week 6, one instructor explained the notion of shared space: "Shared space is the place where you can go to communicate and you and others can come back to it and review it. With technology, shared space makes thoughts and ideas visible through email or a bulletin board system like VaxNotes. ... If you and I were working on a paper and you left a copy of it on the network, then the file it is stored under is our shared space. It is a place we can go to when conversing and reflecting on that conversation."

The task of guiding students' learning is no easy job. In the course, the instructors invented several ways to guide students' learning. The methods of guidance used in the electronic discussion are quite successful on the whole. Most students expressed positive feelings towards the electronic discussion and their learning in the class. One student wrote:

> "I admit that I dread coming to the lab to post notes and reflections about the articles and class discussion. However, like Julie, I recall times in class when there was something I wanted to discuss but for one reason or another, the point was forgotten. Using electronic classrooms as the primary means for discussion would allow us to explore ideas in depth and several ideas at the same time. Students who have a difficult time

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following the class discussions have a chance to catch up. The electronic classroom gives them a tool for reflection and clarification about class discussion. Students may not feel as apprehensive about discussing. That is a tool that benefited all of us."

Three methods of guidance have been invented and implemented with relative successes and failures. First of all, the instructor designed the roles of the starter and wrapper to facilitate the electronic discussion. Also, the introductory discussion questions were meant to guide students' discussion; however, most students disregarded the questions because "they are too hard, long, and difficult to follow."

A second method instructors employed to guide and scaffold students' learning was to build upon students' notes. During the discussion, the instructor added comments to generate more conversation, pushed students to defend their opinions, and answered students' information seeking questions. Of course, due to the larger number of students in class, it was extremely hard for the instructor to meet every student's learning and needs. Some students felt that instructors could add more of their experiences and thoughts about the readings and could answer or comment more on the questions raised by students. Sometimes, they expected less. For example, one student wrote: "I'd like for the comments to be less all-encompassing. Just a nudge here or there would be fine. What the instructor says tends to be taken as the final word on an issue, thus it can stifle conversation." Another student expressed the opposite view: "... I think instructor should pay more attention to lead the discussion and make sure everyone catch the points."

Finally, the instructors utilized the method of role play during the electronic conference. Each student was given a role or could choose one. Some students assumed the role play very well and motivated other peers to contribute more. However, the role play method was not well accepted by some other students, because of their personal learning style. They simply felt that they could not discuss and assume one of the roles simultaneously.

CONCLUSION

This study reveals a promising way of employing a piece of ordinary communication technology to facilitate students' learning and has proven to be quite successful. In the electronic discussion, students selected topics, determined their goals, shared experiences and understanding with peers. Meanwhile, they tried to make sense of the issues and the concepts through reading articles and working within their own ZPD with the assistance from instructors and peers. VaxNotes is a "shared space" wherein students can engage in various collaborative learning activities. This is a social and intellectual tool for facilitating understanding and supporting the social construction of knowledge.

The study has reported some pioneering efforts in using computer mediated communication tools in instruction. More empirical research should be conducted to verify the participant and note coding schemes and models of analysis used here. More studies need to be conducted to establish practical guidelines for incorporating computer mediated tools into classrooms, because before one can begin to look at effective implementation of a new technology, one must understand how that technology can be used both mechanically and pedagogically. The field is promising and wide open to researchers from many disciplines.

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